Another objection often presented against this plan of course is that it is hard, and numerous plans have been introduced purporting to give a course that will be much simpler for the student, and incidentally for the teacher too; and I do not doubt that they are so. If the same values can be had from a simpler course, all would readily adopt it; but such does not seem true. The simple courses uniformly consider, in the main, isolated topics illustrated in the highest groups of plants. That the course here advocated is more difficult is not an argument against it. Hard work develops strength. A real knowledge of the scientific method of thinking, of the essential principles of plant life, real culture, comes only through hard work. And I firmly believe that more will be done for high-school students by subjecting them to such a logical, definitely organized course, involving all the leading fields of plant study, teaching the relative evolution of plants of various groups from the points of view of structure, ecology, and physiology combined. The course is one in botany, not one in any specialized field of botany.

Professor B. P. Colton, of the State Normal School at Normal, read a paper from the standpoint of zoölogy, upon

THE PHASES OF ZOÖLOGY THAT NEED TO BE EMPHASIZED IN SECONDARY EDUCATION.

1. We must teach by means of types. We wish the student to get a good general knowledge of the animal kingdom as a whole. From the bewildering array of animals presented by nature the teacher must select a few forms as representatives. From the knowledge gained from these type-forms the student proceeds to reading about related forms. That is, on the basis of real knowledge, gained from actual study of the type, he builds a structure of information through reading and hearsay. This proceeding is based on the doctrine that real knowledge comes only through the senses, and that what we get in other ways is information rather than knowledge. Or, to put it in another way, the knowledge of the type is a peg firmly driven

into a wall, on which much information may be hung. Without this support information falls to the ground; or, going back to the former figure, no superstructure can be reared except on a solid foundation.

Such a system of type-study has become widely adopted. It is the outcome of the plan introduced by Huxley, and the book that first set forth this scheme was the *Practical Biology* of Huxley and Martin. But the trouble with the type-system, as ordinarily followed, is that it often stops short with the study of anatomy, including perhaps microscopic anatomy.

2. We must study these types as *living things*. Their life-processes must be studied as well as their structures. I am not advocating the neglect of the study of structure. Nothing can take the place of such study. No one can understand the working of any machine without having at least a fair knowledge of its structure; and this must be first-hand knowledge. No mere reading will suffice, no matter how well illustrated. Neither will demonstration by the teacher serve as a full equivalent for dissection by the student himself. Of course there are many occasions when it will be advisable for the teacher to do the work of dissection, or to resort to models or even to charts. But nothing can take the place of the actual dissection of the type-forms by each individual student, under the close supervision of the experienced teacher. But the physiology of each type should be studied as carefully as its anatomy. Indeed, it is the chief purpose of the study of anatomy that one may understand the work of each part, and how the mechanism, as a whole, operates. Biology is the study of life; but far too often we have made it a study of death.

It is evident that there are many difficulties in the way of such study. Many of the life-processes are still ill understood, even in the animals most favorable to study and on which most time has been spent. Probably much of our animal physiology is far too largely based on what we think we know of human physiology. But this does not excuse us from the task before us. There are especial difficulties in the way of studying the life-processes of animals as we find them in the field. Their

natural shyness, and the various means they have of concealment and escape, present almost insuperable obstacles. It is often exceedingly difficult to see the animals themselves, to say nothing of the effort to learn how they "live and move and have their being." We must bring them into the laboratory. While their surroundings will be more or less artificial, this will not make any essential difference in the physiological processes. A frog will breathe in the same way when in a glass jar as he would in a pond, and the chances of seeing how he does this are greatly increased by confining him within transparent walls. So the study of animal physiology must be largely confined to the laboratory. Cages and aquariums must be provided. We must endeavor to imitate their natural surroundings so far as possible; in other words, we must make them feel at home, yet in such conditions that we may watch them. Thus we may learn how they jump or swim, what and how they eat, how they breathe, how they are affected by heat and cold, light, sound, touch, etc.

3. Not only must the life of an animal be studied, but its life in relation to its natural surroundings. Its colors in relation to the colors of its environment must be closely noted. Its effects on the plants or animals on which it feeds must be observed and carefully considered. Its enemies and its mode of protection, concealment, or escape must be patiently discovered. To learn all these things, we must resort to field study. The natural surroundings can be learned only by observation of the animal in its own home. Many of these points would pass undiscovered after any amount of laboratory study. For instance, most people find it difficult to see a fish when looking down into the water, even after its location is pointed out by the experienced observer. The color of its back so closely matches the muddy or sandy bottom that only those who develop the keen sight of a kingfisher, heron, or fish hawk discover it.

The hunter and the fisher, if successful, are so because of close field study. Their methods, perhaps not their spirit, are to be commended. Substituting the camera for the gun, the field student will do well to imitate the dress and method of approach of the skilful sportsman. In hunting deer perhaps the

best single rule is "see the deer before the deer sees you." So, if one can approach, unobserved, any animal close enough to observe its natural actions, he is master of the situation. Some animals have little timidity, but others will tax to the utmost the skill and patience of the observer. Since many of the animals that are preyed upon are constantly on the watch, even the sense of hearing never going to sleep, it is indeed a triumph to gain near approach, and one who can get a good photograph of such an animal may congratulate himself on his success, and claim that he has "beat the animal at his own game."

I am well aware of the difficulties in the way of field study. In the first place, it costs money to get into the field. Even in the country schools—I mean the high schools of towns and smaller cities—it involves expense to get out into desirable territory. Of course, some observations may be made on such forms as insects and birds, and occasionally various other forms; but most animals avoid civilization, and dislike too dense a population. In my own school we are ten miles from any considerable stream. Hence it is difficult to make much field study of fishes, clams, crayfishes, water birds, etc. Then, too, it takes too much time to make the desired number of observations. Many pupils have home work that occupies most of their spare time on afternoons and Saturdays. Some pupils have leisure, and some have conveyances by which they can get out into the country, but these are exceptions.

But, in spite of all these difficulties, we should aim to have each student do some field work. Work may be assigned to each pupil according to his opportunity.

As often as possible the teacher should have Saturday excursions, and go with his class and teach them what to look for and how to observe, how to approach animals without frightening them, and show by example how all this is to be done. Van Dyke says that the still-hunter's cardinal virtue is patience. So also the student of live animals must take as his motto, "Patience." Quiet watching often brings better results than industrious tramping. One needs to learn what Charles Dudley Warner calls "the art of sitting on a log." The field-glass puts one nearer his game without alarming it.

In this connection each pupil should read some such books as those of Abbott, Burroughs, or Olive Thorne Miller, to get hints on how much may be learned by patient watching combined with good headwork in outwitting shy creatures.

I am not sure that I can see why the city teacher cannot organize Saturday field excursions almost as well as many of the country teachers. My own classes go two or three times a year at least twenty miles by rail. With all the suburban service and the excellent collecting ground around the city, the chances are almost equally favorable. Be that as it may, the city teacher has one very great advantage in having easy access to a splendid museum and a good zoölogical garden, which perhaps more than offset any disadvantages of his situation.

4. I am not unmindful of the fact that what is known as "systematic work" has been very greatly neglected of late years. In fact, in many quarters it is looked upon with profound contempt. It is a well-known fact, however, that most students who have taken the traditional course in biology find themselves almost lost when they go into the woods or fields. They are among strangers. It is no wonder that they feel lonely in such a situation unless they have human companionship. Even in the country schools the children know only a small part of the animals of their neighborhood. There ought to be frequent use of some such book as Jordan's *Manual of the Vertebrates*.

During the past year I chanced to spend a day in the woods with a teacher of biology, trained in the usual laboratory methods of type-study. He seemed little acquainted with nature. Not having had an introduction, he was ill at ease in the throng of nature's assembly. He knew only ameba and spirogyra, hydra, and marchantia, etc., and they were not present in conspicuous numbers. They did not appear on the committee of welcome. He did not appear to know the beautiful asters and golden-rods, the sociable hazel bushes, nor the magnificent oaks. Perhaps he flattered himself that he recognized only a few of the select. Some minds think they get more by being very exclusive. They dread to appear familiar with the commonplace. The condition of such closet naturalists recalls the well-known adage: "If you

study nature indoors, when you go outdoors you cannot find her."

5. The reading of a book on animal ecology is not zoölogy. I am firmly of the opinion that it is a mistake to have animal ecology precede a study of animal forms and structures. Ecology is a study of the relations of organisms to their surroundings. These relations cannot well be studied until we know the form itself. And the best time to study the relations is soon after becoming acquainted with the animal, while the facts of its form and structure are still fresh in mind. If the work in ecology lag too far behind, the thing to which we wish to find relations has become dim and the relations are not distinct. Ecology should not be massed. It should be distributed through a course in zoölogy. As each form is studied, its place in the world of nature should be considered; how it affects other living beings, and how other living beings affect it; how the external physical conditions act upon it, and how it reacts upon the earth, water, and air on and in which it lives. In my opinion, a good text on animal ecology should be at hand during a course of study in zoölogy, and constantly used as collateral reading in connection with each group or each animal form taken up.

When studying insects, the student continually finds adaptations, such as the protective resemblance of the walking stick to a twig, of the katydid to a leaf, of the butterfly to flowers, of the grasshopper to leaves or soil. He finds many cases of parasitism, and can draw his own conclusions as to the effect of such a life on the animal itself. He finds numerous examples of protective resemblance, and the uses of colors among animals is a never-ending problem of interest. Everywhere he finds the struggle for existence and adaptation to surroundings. Probably, if left to his own observations, he would have a very narrow view of such a subject as the geographical distribution, and he will do well to read on all these topics. The point I wish to urge is that the *beginnings* of such study be based on his own observations. Thus it is real, and may widen out from himself as a center.

Mere reading of ecology is like reading *about* animals; it has no substantial basis. Recall the fable of Antæus, and how he

retained his strength so long as he kept his feet upon earth. Much of our study is more like the paintings of angels in the Middle Ages; human feet paddle the air, or wade through clouds, of no more use than the false wings, tacked on without any backing of muscular machinery. So the student grows weak unless he can trace his theories and general laws to observed facts of his own acquisition.

6. Another phase of zoölogy should also be emphasized, namely, the practical. This is a practical age, and more is demanded of the high school in this line than ever before; in fact, we have a pressing demand for the commercial high school. So we have manual training and domestic science. The botany and zoölogy of the high school ought to have some bearing on the affairs of everyday life. Even if there were no demand for practical results of the science teaching in the high school, it is surely true that zoölogy ought to enable the student to understand more fully something of his relations to the world of animal life. He ought to know something of the insects that destroy the crops of farm and garden. He ought to know how these insects do the damage; he should know their life-histories; in what stage of their development they are injurious. He should be familiar with the common means of combating them, such as spraying, fumigating, etc. He should know something of the care of bees, of the rearing of the silk-worm, of the danger from insects to furs and museum specimens, and the remedies for these troubles. Also the exceeding value of insects in carrying pollen, and effecting cross-fertilization. He should learn the value of most birds to man, in destroying insects. He should learn the food value of fishes, and the facts about the artificial propagation of fishes as shown by the reports of the various fish commissions. He should learn of the process of catching, canning, or otherwise preserving fish and fish products. The discovery of the relation of flies and mosquitoes to disease is one of the later triumphs of modern science. Of these discoveries high-school students should not remain ignorant. The various food preparations from the mammals, such as beef and pork, tallow and lard, hides, hair, glue, and so forth, as well as

the dairy products; and the relation of milk to disease should be at least touched upon. The wool industry, the pearl-button manufacture, and numerous other industries should be made subject-matter of reading, and as much investigation as local establishments will permit.

Two of the main tests of the utility of knowledge are, first, its application in supplying the needs of daily life; and, second, its application in explaining the phenomena of our ever-recurring experience. If the study has taken any hold of the individual, it certainly ought to be available in application to his contact with the facts as he meets them in the world of everyday life. It is not what we can say in the class-room, but what interpretation we are enabled to put upon the phenomena of life-processes as we meet them in our daily walk, and especially what use we can make of them in bettering the condition of life and making life more full of meaning.

7. Although the practical value of these studies is great, if they are rightly conducted, we must not overlook the fact that running through it all we should keep sight of the educational value that ought to be derived from the study. The study of the relations of animals to their surroundings is a constant investigation of cause. The student must ask why an animal has a certain color, form, or habit. He must first learn to observe the facts that come within the range of his experience. Next, he must seek an explanation of these facts. He must become possessed by the idea that every fact has a meaning, and that it is worth his while to think out this meaning. At first he is to be helped; but he should soon learn that he must rely mainly on himself for the solution of most of the problems of animal life. Many of these problems are simple problems in mechanics, such as the question of how the clam opens and shuts its shell. These mechanical problems may be found of all degrees of complexity, from that of the crawling of an earthworm to that of the flight of a bird—a problem that the scientists are still trying to solve, at least in its practical application. But, aside from such problems of motion and locomotion, perhaps the most interesting problems cluster around the word "adaptation."

Here we find a never-ending variety and a source of never-failing interest.

It is sometimes objected that such problems have little value because many of them cannot be answered with exactness, like problems of physics or mathematics. Just herein lies their special value. They teach the student to look for hidden factors and undiscovered conditions which vary the results, and he is prepared in some degree to attempt the solution of social and economic problems, which always have a variable answer because of the uncertainties that are involved wherever we have to deal with problems that concern life. We must constantly cultivate the habit of interpretation, and so train the student that this power shall be developed to a high degree. The world is full of meaning and beauty to those who have the eye and the mind to see it. The fall of the apple suggests to a pig merely the gratification of an appetite; to Newton it suggested the universal law of gravitation. Probably the pig saw the apple as clearly as did the philosopher. Insight was lacking. It is not so much the power of observation that needs cultivation as the power of reflection. We must remove the scales from the mind's eye.

Undoubtedly we must do more than we have done to teach the boys and girls to earn a living. But we must do something more and higher than this: we must teach them how to *live*. As I visit the homes of the humble, or those living in the country, I am not so much impressed by their poverty of worldly goods, though in some places there is somewhat of scantiness. But many, many times have I been impressed with the mental poverty. The barrenness of mind is appalling. While the schools are not wholly responsible for this mental poverty, I hold that the schools are responsible for its continuance. We can open the mind to the light of the intellectual life, and lead to a grasping of something of the meanings of things in the world, and thus make rich and fertile what was an arid waste.

To anatomy we must add physiology, and to this natural history and ecology. We must contemplate, not dry bones, but *life*—life in its fulness and the richness of its many-sided relationships. Not that we are to omit anatomy, though perhaps we

may get along with less of it. "These things ought ye to have done and not to leave the other undone."

Huxley is not responsible for the fact that our courses in biology have been narrow and narrowing. To show his broad view of the subject let me, in closing, quote him:

> To a person uninstructed in natural history a stroll in the country or by the seaside is like a walk through a gallery filled with wonderful works of art nine-tenths of which have their faces turned toward the wall. Teach him something of natural history, and you put into his hand a catalogue of those worth turning around. Surely our innocent pleasures are not so abundant in this life that we can afford to throw away this, or any other, source of them.

Following is an abstract of the paper of Professor Wilbur S. Jackman, of the University of Chicago, upon the subject:

WHAT SHOULD BE EMPHASIZED IN TEACHING BIOLOGY?

Within the lifetime of biology teachers now living the methods of teaching the subject have completely changed. It has not been many years since books like Orton's text-book in zoölogy, used mainly as a reader, furnished the basis for most of the work done even in some colleges. Just as the sciences of chemistry and astronomy were revolutionized, respectively, by the discoveries of Lavoisier and Copernicus, so the work of Darwin began a new era in the teaching of biology. The text-book as a reader was discarded, to be succeeded by the laboratory manual and the scientific treatise. These books were valuable in detailing the minutiæ of method and in showing the form which the results of observation should take. Neither book concerned itself with either the purpose of the study or the breadth of outlook, and the slavish use of the manual has made biology, to speak by paradox, a lifeless study.

Progress in the study of plants and animals in their wider relationships has been retarded by the ancient custom of giving to the studies of botany and zoölogy a tandem presentation; that is, one preceding the other. It is now pretty clearly recognized that any science, socalled, may serve to introduce the student to nature, and that no one study can do more than offer an introduction. The subject of ecology now undertakes to work out the social relations of living things under normal conditions. The application of its principles may be made by the mature student or by the beginner.

Questions relating to material and method in biology are now treated with intelligence and skill, but the question of motive has scarcely been touched. The position of natural science in the lower schools is still tentative, because its mission in the minds of most teachers is still problematical. In answering